The effects of a well-resolved stratosphere on the simulated boreal winter circulation in a climate model

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The impact of stratospheric representation is investigated using the Model for Interdisciplinary Research On Climate Atmospheric General Circulation Model (MIROC-AGCM) run with different model-lid heights and stratospheric vertical resolutions, but unchanged horizontal resolutions (~1.125°) and subgrid parameterizations. One hundred year integrations of the model were conducted using configurations with 34, 42, 72 and 168 vertical layers and model-lid heights of ~27 km (L34), 47 km (L42), 47 km (L72) and 100 km (L168). Analysis of the results focused on the Northern Hemisphere in winter. Compared with the L42 model, the L34 model produces a poorer simulation of the stratospheric Brewer-Dobson circulation (BDC) in the lower stratosphere, with weaker polar downwelling and accompanying cold pole and westerly jet biases. The westerly bias extends into the troposphere and even to the surface. The tropospheric westerlies and zone of baroclinic wave activity shift northward; surface pressure has negative (positive) biases in the high (mid) latitudes, with concomitant precipitation shifts. The L72/L168 models generate a Quasi-Biennial Oscillation (QBO) while the L34/42 models do not. The L168 model includes the mesosphere, and thus resolves the upper branch of the BDC. The L72 model simulates stronger polar downwelling associated with the BDC than does the L42 model. However, experiments with prescribed nudging of the tropical stratospheric winds suggest differences in the QBO representation cannot account for L72-L42 differences in the climatological polar night jet structure. The results show that the stratospheric vertical resolution and inclusion of the full middle atmosphere significantly affect tropospheric circulations.

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